

Estimating Lifetime Probabilities of Dying of Cancer

DevCan mortality calculations are derived from mortality counts from data collected by the National Center for Health Statistics by five-year age groups. DevCan calculates mortality rates based on population denominators from the US Census Bureau. These rates are converted to probabilities using an exponential model, and the probabilities are then applied to a hypothetical population of ten million live births. For each five-year time interval, the system estimates the number in this population that die of other causes and the number that die of cancer. The accumulation of these figures yields the lifetime probability of dying of cancer or of dying from other causes.

The variables ℓ and d represent the living population and deaths from the hypothetical population of ten million births in the cohort as they age. The variable m represents observed cancer rates which are used as input for the DevCan model. In all cases the subscript, x is the beginning of the age interval which the variable describes. Thus, ℓ_{30} is the number of people remaining when the hypothetical population reaches 30 years of age.

ℓ_x = population at age x

d_x^c = cancer deaths from age x to $x + 5$

d_x^o = other deaths from age x to $x + 5$

m_x^c = observed cancer mortality rate from age x to $x + 5$

m_x^o = observed other cause mortality rate from age x to $x + 5$

m_x = observed all cause mortality rate from age x to $x + 5$

The DevCan software begins with 10,000,000 live births in the hypothetical cohort, and then it proceeds to calculate the number alive at the start of each successive 5 year age interval using the iterative equation:

$$\ell_{x+5} = \ell_x - d_x^c - d_x^o$$

Deaths are calculated using an exponential model.

$$d_x^c = \ell_x \left(1 - e^{-5m_x^c}\right) \frac{m_x^c}{m_x}$$

$$d_x^o = \ell_x \left(1 - e^{-5m_x^o}\right) \frac{m_x^o}{m_x}$$

The number of deaths in the last open-ended age group (i.e. age 95+) is defined using the following equations.

$$d_{95+}^c = (\ell_{95+}) \left(\frac{m_{95+}^c}{m_{95+}} \right)$$

$$d_{95+}^o = (\ell_{95+}) \left(\frac{m_{95+}^o}{m_{95+}} \right)$$

The lifetime risk of dying of cancer is computed by summing the number who die of cancer and dividing by the number who enter the cohort, i.e.,

$$\sum_{i=0,5,10\dots 95+} \frac{d_i^c}{\ell_0}$$

DevCan derives age conditional risk by summing mortality values during the age groups in question and then dividing by the population size from the beginning of the age range. The probability of dying from the cancer by age k+5 given that the person is currently of age j is:

$$\sum_{i=j,j+5,j+10\dots k} \frac{d_i^c}{\ell_j}$$

Unlike the age-conditional risk of developing cancer calculations, these calculations assume only that a person is alive, not necessarily alive and cancer-free, at the beginning of the interval.

References

R.C. Elandt-Johnson, N.L.Johnson. Survival Models and Data Analysis, John Wiley and sons, New York, 1980, ch. 10.